

CLAIMS

1. A range image sensor, comprising:

a light source which emits intensity modulated light toward an object space according to a modulation signal of a specific frequency;

5 a light detecting element with photosensitive units disposed to face said object space, each of the photosensitive units receiving light from said object space during an integration period shorter than one period of said specific frequency, and generating an electric charge in response to a quantity of light from the space;

10 a sensor control stage which controls to synchronize each integration period of said photosensitive units with a specific phase of said modulation signal, and pick up each electric charge generated and integrated in said light detecting element from the light detecting element after a detection period corresponding to one or more periods of said specific frequency; and

15 an image construction stage which calculates a distance value for each image element in a range image based on each electric charge picked up by said sensor control stage to construct the range image, said distance value representing, when at least a physical object is in said object space, distance up to the physical object;

20 wherein: said detection period includes different detection periods; and

said image construction stage calculates a distance value for each image element in said range image based on each electric charge picked up after a specific detection period of said different detection periods by said
25 sensor control stage,

said specific detection period being one of one or more detection periods during which said light detecting element does not reach saturation, and being one detection period during which a value related to the quantity of light received from said object space becomes maximum of that of the one
5 or more detection periods.

2. The range image sensor of claim 1, wherein:

said sensor control stage controls to synchronize each integration period of said photosensitive units with each of a set of phases different from
10 each other in said modulation signal, and pick up one set of electric charges corresponding to the one set of phases at every image element in said range image after at least said specific detection period of said different detection periods; and

said image construction stage calculates a distance value for each
15 image element in said range image based on one set of electric charges picked up at every image element in said range image after said specific detection period.

3. The range image sensor of claim 2, wherein:

20 said sensor control stage controls to pick up one set of electric charges corresponding to said one set of phases at every image element in said range image after each of said different detection periods; and

said image construction stage selects said specific detection period out of said different detection periods, and calculates a distance value for
25 each image element in said range image based on one set of electric charges

picked up at every image element in said range image after the specific detection period,

said specific detection period being one of one or more detection periods during which a value obtained from one set of electric charges picked
5 up at every image element in said range image after each of said different detection periods does not exceed a value predetermined based on saturation level of said light detecting element, and being one detection period during which the value obtained from one set of electric charges becomes maximum of that of the one or more detection periods.

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4. The range image sensor of claim 2, wherein said specific detection period is one of one or more detection periods during which a value of one set of electric charges picked up at every image element in said range image after each of said different detection periods does not exceed a
15 prescribed value corresponding to said saturation level, and is one detection period during which the value of one set of electric charges becomes maximum of that of the one or more detection periods.

5. The range image sensor of claim 2, wherein said specific
20 detection period is one of one or more detection periods during which a value of maximum electric charge for each of one set of electric charges picked up at every image element in said range image after each of said different detection periods does not exceed a maximum threshold value predetermined based on said saturation level, and is one detection period during which the
25 value of maximum electric charge becomes maximum of that of the one or

more detection periods.

6. The range image sensor of claim 2, wherein said specific detection period is one of one or more detection periods during which a mean value with respect to one set of electric charges picked up at every image element in said range image after each of said different detection periods does not exceed an average reference value predetermined based on said saturation level, and is one detection period during which the mean value becomes maximum of that of the one or more detection periods.

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7. The range image sensor of claim 3, wherein, when said specific detection period is not selected or a first specific detection period as said specific detection period is shorter than prescribed length, said image construction stage:

15 (i) selects a second specific detection period out of said different detection periods at every one or more phases of said one set of phases with respect to a specific image element for which said specific detection period is not selected or the first specific detection period shorter than said prescribed length is selected;

20 (ii) corrects one or more values obtained from one set of electric charges picked up with respect to the specific image element after the second specific detection period based on a rate of length of the corresponding second specific detection period, and calculates one set of values; and

(iii) calculates a distance value for the specific image element based on the one set of values;

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said second specific detection period being one of one or more detection periods during which a value obtained from electric charge corresponding to the one or more phases of said one set of phases does not exceed a value predetermined based on said saturation level, and being one
5 detection period during which the value obtained from electric charge becomes maximum of that of the one or more detection periods.

8. The range image sensor of claim 2, wherein said image construction stage calculates a comparison value by applying at least a value
10 obtained from one set of electric charges picked up by said sensor control stage to a function with respect to the quantity of light received by each of said photosensitive units, and selects said specific detection period by comparing the comparison value with a prescribed threshold value.

15 9. The range image sensor of claim 1, wherein said comparison value is a mean value with respect to an electric charge corresponding to a quantity of light received by said photosensitive units during one or plural periods of said specific frequency.

20 10. The range image sensor of claim 1, wherein, when a distance value for a specific image element in said range image is not calculated, said image construction stage allocates an alternate value to the specific image element.

25 11. The range image sensor of claim 10, wherein said alternate

value is a past distance value for said specific image element.

12. The range image sensor of claim 10, wherein said alternate value is a mean value with respect to a distance value of each image element
5 around said specific image element.

13. The range image sensor of claim 2, wherein said image construction stage calculates one set of integrating electric charges at every image element in said range image and calculates a distance value for each
10 image element in said range image based on each one set of integrating electric charges, said one set of integrating electric charges being obtained that each electric charge in a plurality of the specific detection periods is added up at every same phase of said one set of phases.

15 14. The range image sensor of claim 13, wherein:
said light detecting element includes pixels each of which is consisted of two or more neighboring photosensitive units in said photosensitive units, each of the pixels mainly generating and integrating two or more electric charges at its two or more neighboring photosensitive units in
20 synchronization with two or more phases of each group obtained by dividing said one set of phases into groups each of which includes two or more phases, respectively;

said sensor control stage controls to change synchronization timing of each integration period of two or more neighboring photosensitive units in
25 each of said pixels with respect to each phase of a corresponding group of

said groups so as to mutually interchange each phase of the corresponding group with respect to the neighboring photosensitive units, and pick up each electric charge mainly generated and integrated during each integration period corresponding to each phase of said each group at every pixel after at least said specific detection period of said different detection periods; and

said image construction stage combines each electric charge picked up at every pixel by said sensor control stage with one set of electric charges corresponding to said one set of phases, and calculates a distance value for each image element in said range image based on the one set of electric charges.

15. The range image sensor of claim 13, wherein:

a plurality of neighboring photosensitive units are set as a unit of arithmetic;

said sensor control stage changes an integration period of each photosensitive unit of the unit of arithmetic to an integration period of a different phase of said one set of phases at every said specific detection period; and

said image construction stage makes a value of an image element in said range image out of distance found by using an electric charge added up a period of time in which each photosensitive unit receives light from said object space, said light being received same number of times each in all integration periods of said phase.